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# THE BLUEGRASS WEBWORM[1]

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## INTRODUCTION

Although the bluegrass webworm, *Crambus teterrellus* Zincken, is widely distributed throughout the eastern part of the United States, its comparatively small size and inconspicuous coloring seem to have rendered it almost immune from the attention of entomologists. Over a portion of its range it is probably the most abundant of all Lepidoptera during much of the summer, and yet scarcely two pages have ever been written about its life history and habits. Murtfeldt made some observations on it in the summer of 1892 (*14*),[4] her attention being attracted by its great numbers. Practically all other published allusions to it are mere records of occurrence, and its complete bibliography comprises hardly more than a score of references. Since it is of considerable economic importance the writer has assembled here all the available information relative to this species.

Although this insect is perhaps not more strictly limited to bluegrass for food than are some other species of the genus, the common name given it by Murtfeldt has here been adopted with slight change. The name seems fitting because over the limestone districts of central Kentucky and Tennessee, where the insect is a dominant species, Kentucky bluegrass is also one of the dominant plant species. Although locally abundant during favorable seasons at points far removed from this territory, it probably is more continuously abundant over the bluegrass regions of Kentucky and Tennessee than in any other part of its range.

[1] This bulletin constitutes No. VI of the series of Contributions to a Knowledge of the Crambinae of North America. No. I, *Crambus hemiochrellus* Zeller, appeared in Annals of the Entomological Society of America for March, 1918, and II, *Crambus laqueatellus* Clemens, appeared in the June, 1922, issue of the same journal. The third paper, entitled "Striped Sod Webworm, *Crambus mutabilis* Clemens," appeared in the Journal of Agricultural Research, Vol. XXIV, No. 5, and the fourth, "The Silver-Striped Webworm, *Crambus praefectellus* Zincken," followed in the same number. No. V was published as U. S. Department of Agriculture Technical Bulletin No. 31, entitled "The Larger Sod Webworm."

[2] Resigned Jan. 31, 1927.

[3] Meager facts already in print have been freely utilized, but the great majority of the data are the results of several years' study by the writer, assisted by various men, of whom C. C. Hill, and especially W. B. Cartwright, deserve mention for their efficient cooperation.

[4] Italic numbers in parentheses refer to Literature cited, p. 24.

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## SYSTEMATIC HISTORY

*Crambus teterrellus* was first described by Zincken (*21, p. 252*) in 1821, and placed in the genus Chilo, which at that time comprised substantially all of our present subfamily Crambinae. His specimens came from the vicinity of Savannah, Ga.

No further reference seems to have been made to this species until it was redescribed in 1860 by Clemens (*6, p. 203*) as *Crambus camurellus*. Zeller quickly noted this error, and in 1863 (*18, p. 27*) reduced the new name to a synonym, a decision in which all later writers have concurred. Ascribing the first syllable "te" to a typographical error, Zeller (*18, p. 27*) changed Zincken's original *teterrellus* to *terrellus* and so used it in all of his references to this insect (*19, p. 539; 20, p. 35*). Grote (*11, p. 78*), and Smith in his earlier lists (*15, p. 346; 16, p. 468*), used the spelling *teterellus*, but since then, without exception, the original form has been employed.

Until 1893 all references in literature to this insect were purely systematic, being either descriptions or records of occurrence. In that year, however, there appeared from the pen of Murtfeldt (*14, p. 53–54*) a short article giving a brief account of the insect's larval habits as observed by her near St. Louis. The following year Felt (*7, p. 66–67*) summarized Murtfeldt's paper and quoted liberally from it, but added nothing to her facts. From that time until now, except for some brief accounts by the present writer (*1, p. 116, 118; 2, p. 114–123; 3, p. 12*) nothing concerning the bionomics of this species has appeared. It has of course been included in check lists and catalogues; and various authors, including Hine (*12, p. 26*), Gillette (*9, p. 11*), Laurent (*13, p. 170*), Brimley (*4, p. 41*), Smith (*17, p. 530*), and Britton (*5, p. 107*), have recorded its occurrence in different States.

## GEOGRAPHICAL DISTRIBUTION

The writer has been able to assemble a great number of occurrence records for this species and to determine with some accuracy the limits of its distribution. The westernmost records are from San Diego, Tex., Golden and Fort Collins, Colo., and Sioux City, Iowa. The northern limit is a line running almost due east from Sioux City. Hine (*12, p. 26*) reports that it occurs "only sparingly" in Ohio, although it has been taken as far north as Columbus. Felt (*7, p. 66*) states definitely that it is found in New York State, though it is not present in Ithaca; it evidently must occur only in the southeastern portion of the State. It has been taken on Nantucket Island, off the coast of Massachusetts. Grossbeck (*10, p. 125*) says that it "extends to Maine, Missouri, and Texas," but no definite record from Maine is known to the writer. Extensive collections of Crambinae in Minnesota and the Dakotas have failed to reveal its presence in those States. Although it has not been recorded from there, it doubtless occurs in at least a portion of Nebraska. There are dependable records of its presence in every State south and east of the limits above named, except Oklahoma, Delaware, and Rhode Island, in all of which it doubtless occurs. The southernmost points from which records have been received are Brownsville, Tex., and Miami, Fla. In 1887 the late F. M. Webster noted the insect as "excessively abundant" at Ashwood, La., and Forbes (*8, p. 220*) records it as "the dominant species in Alabama, Mississippi, and Louisiana."

The accompanying map (fig. 1) shows at a glance the territory at present known to be inhabited by this species.

Over some portions of this territory the species is not prominent, but throughout a section including Tennessee, Kentucky, and southeastern Missouri, and possibly in places in other States, it is the dominant species during practically the entire summer, greatly exceeding in numbers all other species of Crambus combined. In the States to the north of the Ohio River its preponderance is usurped by *Crambus trisectus*.

The following list names the States from which occurrence records have been obtained, together with the month and day of month of first and last records and the intervening months in which the moths have been reported. A query denotes uncertainty as to date. The list is very incomplete, but will serve as a basis for future work.

| *State* | *Month and day* |
|---|---|
| Alabama | ? |
| Arkansas | June 24, August 11. |
| District of Columbia | June 3, August, September. |
| Florida | February 12, April, May, June, July 3. |
| Georgia | ? |
| Illinois | May 24, June, July, August, September, October 9. |
| Indiana | June 28, July, August, September, October 5. |
| Iowa | July 5. |
| Kansas | July 27, August 8. |
| Kentucky | June 9, July, August 11. |
| Louisiana | April 17, July 24. |
| Maryland | August 7–30 |
| Massachusetts | ? |
| Mississippi | May 16, June, August 3. |
| Missouri | May ?, June, July, August 16. |
| New Jersey | June 3, July, August, September 1. |
| North Carolina | May 19, June, July, August 15. |
| Ohio | August 28. |
| Pennsylvania | June 20, July, August, September 12. |
| South Carolina | September 10–12. |
| Tennessee | May 3, June, July, August, September, October 16. |
| Texas | March 2, April, May, June, July, August, September, October 7. |
| Virginia | July 15, August, September 23. |
| West Virginia | ? |

## ECONOMIC IMPORTANCE

Judging from the slight attention paid by economic entomologists to the bluegrass webworm, one would naturally conclude that it causes little or no damage. This, however, is not the case. A species present in such great abundance as this one often is, and using as its primary food a grass as valuable as Kentucky bluegrass, must certainly cause appreciable loss, but loss difficult or impossible to estimate with any degree of accuracy. Here is found the explanation of the slight attention the insect has received. The injury is so insidious that undoubtedly there are thousands of farmers who lose seriously every year and yet do not know that such a pest exists, and have never seen any stage of it except the adult. The principal injury is suffered by pastures, meadows, and lawns. During seasons of abundant rainfall the plants themselves are seldom injured, and the only loss is the actual quantity of grass eaten by the worms, but this is no inconsiderable item. During dry periods in midsummer, however, there is not only the loss from the grass eaten but

also, and more serious, the injury to the plants themselves. When the plants are having difficulty in maintaining themselves and are without opportunity to recuperate, the extra drain to which they are put in having every green shoot and particle of leaf searched out and eaten kills all but the very strongest.

Considerable areas of bluegrass pasture are often seen which are completely dead, or have only an occasional living plant when rains finally give relief. Coming at times of drought, this injury is usually, and quite naturally, ascribed to drought alone; but without doubt the damage is greatly accentuated by the presence and work of the larvae here discussed. The writer has no record of injury caused by this species to cultivated crops, and its destructiveness seems to be limited entirely to areas more or less permanently in sod.

FIGURE 1.—Map of the United States, showing the known distribution of the bluegrass webworm, *Crambus teterrellus*

## SEASONAL HISTORY

Murtfeldt (*14, p. 53*) states that the moths are most abundant "about the first of August." Felt (*7, p. 66–67*), apparently misreading this statement, says that "the adults do not fly till August." Both of these authors are evidently of the opinion that there is only one generation annually, the insects hibernating as partly grown larvae.

In Tennessee, where the only fairly complete studies of this species have been made, the first flight of moths occurs early in May. These are the moths developing from the overwintering larvae, and the exact date of their appearance varies but slightly from year to year. After their first appearance they increase rapidly in numbers, and throughout the month they are common, and often exceedingly abundant, in every grassy place. During June their numbers gradually decrease, and toward the latter part of the month, especially if the season is dry, there is sometimes a period of several days in which they are scarce or absent.

Early in July the moths of the second flight appear. They rapidly increase in number and continue abundant throughout the rest of the month and in August. Although moths are present continuously through August, they decrease in number during the middle and latter part of the month. In September, unless seasonal conditions interfere, there is a third fresh emergence. The moths rapidly disappear toward the end of this month, and after October 1 a specimen is rarely seen. The latest available record of their appearance in Tennessee gives the date as October 16.

In Tennessee, therefore, there seem to be three broods each year, the moths maturing in May, July, and September, respectively. The first flight of moths in May is fairly distinct; after it there is a rather definite pause before the appearance of the second flight. The interim between the second and third flights, however, is not so marked, and scattering individuals are usually present during August. The variation in the time required for development is so great that toward the end of the season the generations overlap to a considerable extent. The data obtained from rearing cages fully bear out the conclusion, derived from field studies, that three generations annually are possible.

The time of appearance and the abundance of the moths are also affected to a noticeable degree by meteorological conditions. A very hot, dry period of three weeks or more at any time during the summer causes a great reduction in the number of moths present, and copious rains succeeding such a period are followed at an interval of a week or 10 days by the appearance of a large number of freshly emerged moths. Apparently the larvae approaching or reaching full development during such a dry period lie quiescent for some time, instead of pupating immediately, but resume their development when supplied with moisture. It has also been observed that during a season having plentiful and well-distributed rainfall the moths appear in much greater numbers than during one with insufficient or irregular rainfall. It is evident that a continuous growth of young, tender grass is essential to the welfare of the larvae, especially while they are small, and that the mortality is very great among larvae hatching when the ground is dry and hot and the grass rough and closely cropped. It may well be, however, that in spite of their smaller numbers at such a time, the damage actually done to the grass plants is really greater during a dry season than during a rainy one; for then the grass plants need all their vitality to keep alive, and the presence of hordes of hungry larvae industriously searching for the least particle of succulent growth makes it certain that the plants will be given no respite until the larvae either starve or disappear, or renewed rains improve conditions of growth.

## LIFE HISTORY

Nearly 200 individuals of this species were reared from egg to adult in 1915 and 1916, and more or less complete records were kept of the duration of the various stages. After preliminary experimentation two types of cages were adopted as satisfactory for this work. The first, an ordinary 4-inch flowerpot, containing a small sod of bluegrass, covered with a lantern globe closed at the top with a sheet of muslin, served for general rearing when the total length of the com-

bined larval and pupal stages was being observed. The other type, a tin salve or ointment box of ½, 1, or 2 ounce capacity floored with several disks of damp absorbent paper which served to prevent drying out, or the accumulation of excessive moisture, was used when it was desired to keep the larvae under practically constant observation, as in determining the number and duration of the separate instars. Food was supplied to these boxes in the form of leaves of the food plant, cut into short pieces and laid on the blotter. These tin boxes have proved very useful in all the rearing work with crambid larvae, for without disturbing the larvae it is possible to observe the preparation for a molt, to make any measurements or descriptions desired, and to find the discarded head capsule after ecdysis.

In all the rearing work *Crambus teterrellus* has shown greater variation in every way than any other species studied. In number and duration of the various instars, and in the total time required from the hatching of the eggs to the emergence of the adults the variation is so great that averages are of little value. For this reason it has been thought best to present the data as is done in Table 1 rather than to attempt to condense them.

TABLE 1.—*Observations of stages of the bluegrass webworm reared in cages*

| Cage No. | Date eggs were laid | Date eggs hatched | Egg stage | Date of pupation | Larval stage | Date adults out | Numbers and sex | Pupal stage | Total extent larval and pupal stages | Food |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Days* | | *Days* | | | *Days* | *Days* | |
| 16102 [1] | ? | May 14 | ? | ? | ? | July 11 | 1♀ | ? | 56 | Bluegrass. |
| | | | | | | July 12 | 1♀ | | 59 | Do. |
| | | | | | | July 16 | 2♂ | | 63 | Do. |
| | | | | | | July 18 | 1♀ | | 65 | Do. |
| | | | | | | July 20 | 1♀ | | 67 | Do. |
| | | | | | | July 24 | 1♀ | | 71 | Do. |
| | | | | | | July 25 | 1♀ | | 72 | Do. |
| | | | | | | July 28 | 1♂ | | 75 | Do. |
| | | | | | | July 31 | 1♀ | | 78 | Do. |
| | | | | | | Aug. 3 | 1♀ | | 81 | Do. |
| | | | | | | Aug. 7 | 1♀ | | 85 | Do. |
| | | | | | | Aug. 8 | 1♂ | | 86 | Do. |
| | | | | | | Aug. 12 | 2♂ | | 90 | Do. |
| | | | | | | Aug. 26 | 1♂ | | 104 | Do. |
| | | | | | | Aug. 27 | 1♂ | | 105 | Do. |
| 12354G | May 21 | May 27 | 6 | ? | ? | July 6 | 1♂ | ? | 40 | Do. |
| | | | | | | July 8 | 1♂ | | 42 | Corn. |
| 19135 | ? | June 3 | ? | ? | ? | July 28 | 2♀ | ? | 55 | Bluegrass. |
| 15281 | ? | June 12 | ? | July 19 | 37 | July 26 | 1♂ | 7 | 44 | Bluegrass and corn. |
| 15285 | June 6 | ...do... | 6 | July 22 | 40 | July 31 | 1♂ | 9 | 49 | Corn. |
| | | | | July 23 | 41 | ...do... | 1♀ | 8 | 49 | Do. |
| | | | | July 26 | 44 | Aug. 2 | 1♀ | 7 | 51 | Bluegrass. |
| | | | | July 28 | 46 | Aug. 3 | 1♀ | 6 | 52 | Corn. |
| | | | | July 30 | 48 | Aug. 4 | 1♀ | 5 | 53 | Do. |
| | | | | Aug. 10 | 59 | Aug. 18 | 1♀ | 8 | 67 | Bluegrass. |
| 15311 | June 17 | June 22 | 5 | July 26 | 34 | Aug. 2 | 1♂ | 7 | 41 | Do. |
| | | | | July 27 | 35 | ...do... | 1♀ | 6 | 41 | Do. |
| | | | | Aug. 6 | 45 | Aug. 13 | 1♂ | 7 | 52 | Do. |
| | | | | Aug. 9 | 48 | Aug. 17 | 1♀ | 8 | 56 | Do. |
| | | | | Aug. 21 | 60 | Sept. 3 | 1♂ | 13 | 73 | Do. |
| 17109 | June 23 | June 28 | 5 | ? | ? | Aug. 21 | 5♂ | ? | 54 | Do. |
| | | | | | | Aug. 23 | 3♂, 1♀ | | 56 | Do. |
| | | | | | | Aug. 28 | 5♂, 2♀ | | 61 | Do. |
| | | | | | | Sept. 14 | 1♂ | | 78 | Do. |
| 15336 | ? | July 2 | ? | ? | ? | Aug. 10 | 1? | ? | 39 | Do. |
| | | | | | | Aug. 12 | 6? | | 41 | Do. |
| | | | | | | Aug. 13 | 1? | | 42 | Do. |
| | | | | | | Aug. 14 | 2? | | 43 | Do. |
| | | | | | | Aug. 18 | 3? | | 47 | Do. |
| | | | | | | Aug. 19 | 2? | | 48 | Do. |

[1] One mature larva was found in the cage Oct. 28.

TABLE 1.—*Observations of stages of the bluegrass webworm reared in cages*—Contd.

| Cage No. | Date eggs were laid | Date eggs hatched | Egg stage | Date of pupation | Larval stage | Date adults out | Numbers and sex | Pupal stage | Total extent larval and pupal stages | Food |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Days* | | *Days* | | | *Days* | *Days* | |
| 15331 | ? | July 5 | ? | ? | ? | Aug. 14 | 6♂, 1♀ | ? | 40 | Bluegrass. |
| | | | | | | Aug. 17 | 2♀ | | 43 | Do. |
| | | | | | | Aug. 18 | 2♂, 4♀ | | 44 | Do. |
| 12354J | July 3 | July 8 | 5 | Aug. 14 | 37 | Aug. 20 | 1? | 6 | 43 | Do. |
| 16176 | ? | ...do... | ? | ? | ? | Aug. 18 | 1♀ | ? | 41 | Various food, including bluegrass, timothy, crabgrass, Johnson grass, and corn silk. |
| | | | | | | Aug. 22 | 1♂ | | 45 | |
| | | | | | | Aug. 24 | 1♀ | | 47 | |
| | | | | | | Aug. 27 | 1♂ | | 50 | |
| | | | | | | Aug. 30 | 1♂ | | 53 | |
| | | | | | | Aug. 31 | 1♂ | | 54 | |
| | | | | | | Sept. 9 | 1♂ | | 63 | |
| 12354K | July 8 | July 13 | 5 | Aug. 19 | 37 | Aug. 27 | 1? | 8 | 45 | |
| 16199 | ? | July 14 | ? | ? | ? | Aug. 24 | 2♂ | ? | 41 | Bluegrass. |
| | | | | | | Aug. 25 | 1♂ | | 42 | Timothy. |
| | | | | | | Aug. 27 | 1♂ | | 44 | Crabgrass. |
| | | | | | | Sept. 2 | 1♀ | | 50 | Do. |
| | | | | | | Sept. 5 | 1♂ | | 53 | Do. |
| 16201 | ? | ...do... | ? | Aug. 16 | 23 | Aug. 24 | 1♀ | 8 | 41 | Bluegrass. |
| | | | | Aug. 17 | 34 | Aug. 28 | 1♂ | 11 | 45 | Do. |
| 12354M | July 21 | July 25 | 4 | ? | ? | Sept. 7 | 1? | ? | 44 | Rye. |
| | | | | | | Sept. 10 | 1♀ | | 47 | Bluegrass. |
| | | | | | | Sept. 13 | 1♀ | | 50 | Do. |
| 16213 | ? | July 28 | ? | ? | ? | Sept. 7 | 1♀ | ? | 41 | Timothy. |
| | | | | | | Sept. 8 | 1♂ | | 42 | Corn. |
| | | | | | | ...do... | 1♂ | | 42 | Bluegrass. |
| | | | | | | Sept. 10 | 1♂ | | 44 | Timothy. |
| | | | | | | Sept. 11 | 3♀ | | 45 | Do. |
| | | | | | | Sept. 12 | 1♂, 1♀ | | 46 | Do. |
| | | | | | | ...do... | 2♂ | | 46 | Bluegrass. |
| | | | | | | Sept. 14 | 1♀ | | 48 | Timothy. |
| | | | | | | ...do... | 1♀ | | 48 | Bluegrass. |
| | | | | | | Sept. 15 | 2♂, 1♀ | | 49 | Timothy. |
| | | | | | | Sept. 16 | 1♀ | | 50 | Do. |
| | | | | | | ...do... | 1♀ | | 50 | Crabgrass. |
| | | | | | | Sept. 18 | 1♂ | | 52 | Bluegrass. |
| | | | | | | Sept. 20 | 1♀ | | 54 | Crabgrass. |
| | | | | | | ...do... | 2♂ | | 54 | Bluegrass. |
| | | | | | | ...do... | 2♀ | | 54 | Corn. |
| | | | | | | Sept. 22 | 1♀ | | 56 | Timothy. |
| | | | | | | Sept. 26 | 1♂ | | 60 | Bluegrass. |
| | | | | | | Sept. 28 | 2♀ | | 62 | Timothy. |
| | | | | | | Sept. 29 | 1♂ | | 63 | Do. |
| | | | | | | Oct. 5 | 1♀ | | 69 | Corn. |
| | | | | | | ...do... | 1♀ | | 69 | Timothy. |
| | | | | | | Oct. 9 | 1♂, 1♀ | | 73 | Bluegrass. |
| | | | | | | Oct. 13 | 1♂ | | 77 | Timothy. |
| | | | | | | Oct. 17 | 1♀ | | 81 | Crabgrass. |
| | | | | | | ...do... | 1♀ | | 81 | Orchard grass. |
| | | | | | | Oct. 19 | 1♂ | | 83 | Do. |
| | | | | | | ...do... | 1♂, 1♀ | | 83 | Bluegrass. |
| | | | | | | Nov. 6 | 1♀ | | 101 | Crabgrass. |
| 12354D | July 31 | Aug. 5 | 6 | ? | ? | Sept. 13 | 1♂ | ? | 39 | ? |
| | | | | | | Sept. 16 | 3♀ | | 42 | ? |
| | | | | | | Sept. 17 | 3♂, 2♀ | | 43 | ? |
| | | | | | | Sept. 18 | 3? | | 44 | ? |
| | | | | | | Sept. 19 | 6? | | 45 | ? |
| | | | | Sept. 6 | 32 | ...do... | 2? | 13 | 47 | ? |
| | | | | ...do... | 32 | Sept. 21 | 1? | 15 | 47 | Wheat. |
| | | | | ? | ? | ...do... | 6? | ? | 47 | ? |
| | | | | | | Sept. 23 | 1♂, 3♀ | | 49 | ? |
| | | | | | | Sept. 28 | 1? | | 54 | ? |
| 17394 | ? | Sept. 13 | ? | ? | ? | June 13 | 1♀ | ? | 271 | Bluegrass. |

It will be noted, for instance, in the series of larvae reared under cage 16102 that, although hatched on the same day, fed on the same food, and kept under exactly the same conditions, the combined larval and pupal life of those individuals reaching maturity ranged from 58 to 105 days. Also under cage 16213 an even greater variation is noted, the range there being from 41 to 101 days, although in that case the variety of food used may have had some influence on the rate of development.

From these data it is easy to see that in the field the generations can not be distinctly separated. Such is, indeed, the case, and from the time the first moths make their appearance in the spring they are usually continuously present in fluctuating numbers. If one hypothetical individual is followed through the season some idea of the possibilities will be obtained. For instance, beginning with the eggs hatching May 14 (cage 16102) it is noted that the first moth emerged July 11. The first eggs laid by this moth would be hatching about July 18. A normal combined larval and pupal period for this season of the year may be as short as 41 days, which would bring the emergence of the first moths of the next generation to August 28. Larvae resulting from this moth would have time to reach a stage suitable for hibernation, but under the most favorable outdoor conditions could not produce another moth. On the other hand, some of the progeny of the same mother (cage 16102), hatching the same day, matured as late as August 27, and one larva remained active on October 28. It is evident, then, that in the latitude of central Tennessee, where this rearing work was done, there may be as many as three generations or as few as one annually, even from the progeny of the same parent.

As far as is known, the winter is passed only in the larval stage.

## THE EGG

The eggs of *Crambus teterrellus* are very similar to those of other species of the genus. On the whole, they are slightly larger and more elongate and, although varying with different individuals, could in most cases with reasonable certainty be picked out from a mixed lot of eggs. At the extremes the measurements overlap those of other species.

The eggs, which are perfectly dry and nonadhesive even when first laid, are dropped promiscuously by the moths, either while flying or at rest. A surface beneath a light where the moths have been fluttering is usually thickly strewn with them; but it is a hopeless task to attempt to find them in the open, for they are small and easily concealed among the grass stems and débris.

The duration of the egg stage ranges from five to seven days, the usual time in midsummer being five and, during the cooler portion of the season, six or seven days. The record of four days shown in Table 1 (cage 12354M) was due either to very hot weather just at the time or, more likely, to the fact that the examinations had been made at different hours on succeeding days.

An attempt was made to determine the effect of low temperatures on the duration of the egg stage. A quantity of eggs laid during the night of July 7 was divided into two lots of about 500 eggs each. One lot was left in the laboratory at practically outdoor summer temperature, where they hatched July 13, after a 6-day incubation period. The other lot was kept in a refrigerator, on or near the ice, at a temperature ranging from 42° to 58° F., probably averaging about 50°. These eggs developed slowly, but apparently normally, and on August 17 had begun to show the darkening preliminary to hatching. They were then removed from the cold chamber to the warm room. The next day practically all had hatched, the incubation period having been 41 days. How much longer the eggs could have been held at a lower temperature is not known, but the test reveals a very decided

connection between temperature and the length of the incubation period.

It was also found that submerging the eggs in water either retarded or inhibited the development of the embryo. A large number of eggs laid on August 4 were put in a vial and covered with water. Twenty of the eggs were removed each day, dried, and put in a dry vial at room temperature to hatch. Table 2 gives the results in compact form. The asterisk (*) indicates the day of removal from the water, and the figures give the number of eggs hatching each day.

TABLE 2.—*Effect of submergence in water on bluegrass webworm eggs laid August 4*

| Lot No. | Date (indicated by asterisk) in August of removal from water of lots of 20 eggs each, and number of eggs hatching, on dates in August indicated | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 6 | 7 | 9 | 10 | 11 | 12 | 13 | 14 | 16 | 17 | 18 | 19 | 20 | 21 | 23 | 26 |
| 1 | * | | | | 4 | 11 | 1 | 2 | | | | | | | | | |
| 2 | | * | | | | 2 | 13 | 2 | 1 | | | | | | | | |
| 3 | | | * | | | | 1 | 12 | 2 | | | | | | | | |
| 4 | | | | * | | | | | | 14 | | | | | | | |
| 5 | | | | | * | | | | | | 4 | 1 | | | | | |
| 6 | | | | | | * | | | | | 1 | 1 | | | | | |
| 7 | | | | | | | * | | | | 1 | | 1 | | | | |
| 8 | | | | | | | | * | | | | 1 | | | | | |
| 9 | | | | | | | | | * | | | | | 3 | 1 | | |
| 10 | | | | | | | | | | * | | | | | | | |
| 11 | | | | | | | | | | | * | | | | | 1 | 1 |
| 12 | | | | | | | | | | | | * | | | | | |

The eggs when first laid are pure white, not "bright salmon pink" as Murtfeldt describes them. After the first day they become cream colored, and, on the third day, pale lemon yellow, which is somewhat intensified, the tinge being a little richer on the fourth day. This color (closest to pale cadmium yellow in Smith's Glossary) is retained until the day before hatching, when the dark heads become visible through the chorion near one end. Two minute black eye spots are visible after the fourth day.

The larva emerges from an irregular hole near, and partly including, the larger end of the egg. The empty shell is waxy or parchmentlike in texture, transparently iridescent or slightly milky in color, and retains its shape.

### DESCRIPTION

Cylindrical, the ends bluntly rounded, one end slightly more obtuse than the other. Pure white when laid, changing in four days to a rich yellow which is retained until hatching. The chorion longitudinally ridged with from 16 to 18 acute carinae, which occasionally coalesce, especially toward the extremities. Between these carinae are much smaller, cross carinae, about 25 in the length of the egg, dividing the surface into minute quadrangular depressions. The polar areas are uneven but hardly tuberculate.

Measurements (condensed from the measurements of a large number of eggs): Length, maximum 0.5597 mm., minimum 0.4589 mm., average 0.5100 mm.; width, maximum 0.3355 mm., minimum 0.2798 mm., average 0.3070 mm.

## THE LARVA

### HABITS

Just before emergence the larva is bent double inside of the egg, with its head pushed tightly against the angle at the larger end. The first rupture of the chorion seems to be caused by sheer pressure,

and then the opening is trimmed and enlarged with the mandibles. The larva of this species when first emerged is of a uniform pale-yellow color with a slight dusky tinge, the head shining black, and the cervical plate deep fuscous. The head is larger in diameter than the body, which tapers caudad.

The larvae start off at once and travel rapidly until they find a suitable hiding place or become exhausted in the attempt. They spin a thread as they go and if dislodged readily suspend themselves. A vial containing a number of larvae is soon lined with a fabric so delicate as to resemble a coat of white paint.

The larvae are negatively phototropic and positively geotropic, and when given the opportunity soon conceal themselves among the leaf bases of a grass plant. They do not prefer the trough of a leaf in which to begin feeding, but begin at once to construct retreats by webbing together the sand particles of the surface of the earth. Closely opposed leaves are often webbed together to form a tube, within which the larva lives and feeds. More or less fine green excrement is placed in this webbing, and the protective net is soon opaque. If disturbed, the larva quickly seeks the most opaque portion of its burrow, and, if further harassed, coils itself into a tight, flat helix.

At first only the surface tissue of the leaf is eaten, and the veins and tougher membranes are left, but as the larvae become larger they notch the leaves near the base and finally cut them off completely. Larvae placed on a small wheat plant were unable to feed satisfactorily at the base of the plant, and ensconced themselves on the leaves, where their feeding soon became apparent as small whitish pits on the upper surface, each pit roofed by a delicate web of silk bearing particles of excrement in its meshes. The larvae remained under these webs until they became too large for concealment. The area skeletonized by each larva during the first instar was about 5 mm. long by 0.5 mm. wide.

When the larvae become too large to conceal themselves longer in their first retreats among the leaf bases, they construct other, larger ones, radiating from the plant along the surface of the ground. The retreats made by the larvae of this species are not so carefully built as those of most of the other species, but look like haphazard affairs. Instead of being complete tubes lined with silk, they are merely tunnels roofed with sand and earth particles held together with silk, and often with the bare earth for a floor. Murtfeldt (*14, p. 53*) notes that the quantity of web tubing produced was extensive, out of all proportion to the size of the larvae. There are often several radiating passages, each from 10 to 40 mm. long, within any of which the inmate may take refuge when danger threatens. These passages end close to the base of the plant, and it is evident from their position that the larvae feed for the most part directly on the plant. Occasionally, when in the proper position, a leaf may be cut off at the base and drawn into the mouth of the burrow so that the larva can feed without exposure. The outlying ends of these shelters are packed with green granular excrement, and as they become crowded or too small, others are constructed and filled in turn. In the field the sight of a tuft of grass with many of its leaves cut cleanly off close to the base and the dry green frass from it seen when the surface of the earth is disturbed are evidence of the near-by or recent presence of one of these larvae.

In addition to these flimsy feeding burrows at the surface there is often found a much more carefully constructed silk-lined tube, from 10 to 20 mm. long, standing perpendicularly in the earth. It is smoothly lined with silk, and when removed from the earth feels rather stiff and firm to the touch. The upper end is closed by an ingenious device consisting of two lips of unequal size, constructed of silk and covered outwardly with sand or particles of earth, affording almost perfect concealment. The larger lip is hood-shaped; the smaller tightly closes the opening, or may be left agape at the will of the occupant. This safer retreat is built later in life as the larva approaches maturity. It seems to serve as a place of more permanent refuge, and to be resorted to during ecdysis and during the daytime when the surface shelters become too hot and dry for comfort. Leaves are sometimes drawn into these perpendicular burrows, but they are kept clean and free from excrement.

## MOLTING

The act of molting was several times observed, and as the process was exactly similar in each instance the notes describing the molt at the end of the first instar are quoted herewith:

> The new head, very pale except for the black spots which show plainly on the genae, can be seen between the old head and the shining cervical plate. After lying quietly beneath the sheltering web for some hours, the larva began a twitching motion. After a little gentle writhing and twisting, the skin ruptured transversely just back of the old head, leaving it free of skin. The rupture completely encircled the body along the caudal margin of the head. The skin was so transparent and diaphanous that it was difficult to see the exact edge, and its position could be determined by the location of the cervical plate, which remained with this skin and moved backward with it. The skin did not further rupture, and its presence was not apparent until it began to wrinkle up on the last two or three segments. As the cast-off portion encircled the body of the larva, it was constricted as by a belt, and often several motions were necessary to force the skin past one segment. As it passed, the setae, which had lain pressed to the body under the old skin, sprang erect. After the center of the body was passed the skin moved more rapidly, a segment at a time. The cast skin was finally deposited against the leaf, and terminated at the opposite end by the cervical plate. There was no rupture in it other than the one around the neck next the head. While the skin was being cast, the head and anterior portion of the body remained motionless, the old head still in place and including the mouth parts and ventral portion of the new head. When the skin was disposed of, the old head was quickly loosened by a wiping motion of the head against the leaf surface. The entire operation did not occupy more than 15 minutes. The newly molted larva is pale with a pinkish tinge to the body, head white or transparent, mouth parts yellow, the lateral spots on the genae jet black. The internal muscles of the head with their converging fibers show plainly through the epicranium. The cervical plate is transparent, and the caudal segments of the body are very pale. In a couple of hours the head and cervical plate have darkened, and the body has assumed a dusky hue.

## NUMBER OF INSTARS

The number of instars through which larvae of this species pass before pupation varies widely, more so than in any other of the species studied. Of 14 individuals whose records are at hand, two passed through 7 instairs, six through 8, five through 9, and one through 10 instars, prior to pupation. This last number does not by any means exhaust the possibilities, for several larvae far exceeded this number; however, they appeared to be abnormal and finally died either as larvae or while attempting to pupate. As is clearly shown in Table 2,

which gives instar measurements, larvae passing the eighth instar did not increase in size, but merely existed, feeding slowly and being apparently in perfect health. The writer has records showing that some of these larvae reached the twentieth instar before finally succumbing.

Another interesting observation was made several times in the course of the work on this species. For some reason a larva failing to molt normally would emerge from that trying experience with mandibles so deformed that feeding was impossible. Instead of dying, it would lie about the box several days, and at about the normal time molt again, perhaps bringing its mouth parts back into normal condition, without having fed in the meantime. In a few instances the deformed condition of the mouth parts persisted through two and even three instars, but the larva survived, and when it finally became normal it resumed feeding as if nothing had happened.

In the duration of the various instars this species also shows somewhat more variation than is usual in the genus. Forty larvae in cage 15285, and 30 in cage 15311, were kept under constant observation to determine the length of the various instars. The larvae of the former series hatched June 12, and those of the latter June 22. When the records for each series were tabulated they were found to be in such close agreement that they were combined in Table 3.

TABLE 3.—*Duration of instars and of larval and pupal stages of larvae reared under cages Nos. 15285 and 15311. (Hatching of June 12 and June 22)*

| Instar | Duration | | | Number averaged |
|---|---|---|---|---|
| | Maximum | Minimum | Average | |
| | *Days* | *Days* | *Days* | |
| 1 | [illegible] | [illegible] | [illegible] | [illegible] |
| 2 | [illegible] | [illegible] | [illegible] | [illegible] |
| 3 | [illegible] | [illegible] | [illegible] | [illegible] |
| 4 | [illegible] | [illegible] | [illegible] | [illegible] |
| 5 | [illegible] | [illegible] | [illegible] | [illegible] |
| 6 | 10 | 2 | 4.7 | [illegible] |
| 7 | 11 | 3 | [illegible] | [illegible] |
| Prepupal 7 | [illegible] | [illegible] | [illegible] | [illegible] |
| Prepupal 8 | 12 | 4 | 6.[illegible] | 12 |
| Prepupal 8 | 18 | 6 | 10.3 | 6 |
| Prepupal 9 | 9 | 4 | 7.0 | 3 |
| Prepupal 9 | 11 | 7 | 9.0 | 3 |
| Prepupal 10 | 9 | 9 | 9.0 | 1 |
| Summary | | | | |
| Stage | Duration | | | Number averaged |
| | Maximum | Minimum | Average | |
| | *Days* | *Days* | *Days* | |
| Larva | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Combined larval and pupal | [illegible] | [illegible] | [illegible] | [illegible] |

It can be seen at a glance that the range for each of the instars and for the total larval life is unusually great. The instar preceding pupation, whichever one it may be, is always the longest of any in

the life of that individual. For that reason, it would not be accurate to average them with those of other larvae with a different number of instars; they are therefore listed separately as "prepupal" instars.

### FOOD PLANTS

These larvae seem not at all particular about their food provided it is grass. Larvae were reared wholly or in part on Kentucky bluegrass (*Poa pratensis*), wheat, rye, timothy, crabgrass (*Syntherisma sanguinalis*), Johnson grass (*Sorghum halepense*), orchard grass (*Dactylis glomerata*), pigeon grass (*Setaria glauca*), and corn, both leaves and fresh silk. Of the foregoing food plants Kentucky bluegrass is by far the one most commonly fed upon. Young larvae refused to eat leaves of Johnson grass, but later fed on them readily. Some larvae were given moss of several species, and, although they nibbled it slightly, they showed decided preference for grass of any sort. Cowpea leaves were offered and refused. There are doubtless many species of grass, in addition to the above-named kinds, on which the larvae will feed and thrive.

### DESCRIPTION OF INSTARS

The ability of the larvae to grow and mature on starvation rations, if necessary, results in a corresponding variation in the length of the body and width of the head of the larvae, especially in the later instars. Because of this overlapping it is much more difficult to say with certainty to which instar a larva of this species belongs than is the case with many of the other species studied. It is probable that seven or eight is the normal number of instars with these larvae, as up to that number there is a fairly constant and regular increase in size. The variation in size of the larvae in the different instars is shown in Table 4.

TABLE 4.—*Larval measurements of the bluegrass webworm*

| Instar [1] | Number [2] | Width of head | | | Length [illegible] [3] |
|---|---|---|---|---|---|
| | | Maximum | Minimum | Average | |
| | | *Mm* | *Mm* | *Mm* | *Mm* |
| 1 | (?) | 0.212 | 0.194 | 0.205 | 1-2 |
| 2 | 9 | .317 | .247 | .280 | 2-3 |
| 3 | 21 | .466 | .373 | .408 | 2.5-3.5 |
| 4 | 21 | .653 | .466 | .560 | 3-5 |
| 5 | 9 | .933 | .653 | .793 | 5-7 |
| 6 | 10 | 1.026 | .746 | .914 | 6-11 |
| 7 | 13 | 1.213 | .932 | 1.050 | 7-13 |
| 8 | 11 | 1.399 | 1.026 | 1.200 | 9-13 |
| 9 | 5 | 1.212 | 1.119 | 1.166 | (?) |
| 10 | 4 | 1.399 | 1.166 | 1.212 | (?) |
| 11 | 3 | 1.399 | 1.212 | 1.333 | (?) |

[1] [illegible] 18, 1.399 mm.; 19, 1.399 mm.
[2] [illegible]
[3] [illegible]

Instar 1. Head deep fuscous to black; cervical plate fuscous, slightly paler than head. Body pale yellow before feeding, almost transparent, especially [illegible], and tapering evenly back from cervical plate to the rather narrow [illegible]. The ingested [illegible] appears as a dull brown spot moving gradually through the body. After feeding the body becomes cylindrical and dusky green in color from the intestinal contents. The head and body [illegible]

from smaller clear areas in the chitin. The pinacula are concolorous with the body and inconspicuous. Under higher magnification the skin appears minutely granular and is covered very lightly with a saffron overcolor.

For the arrangement of the pinacula and setae in the later instars see Figure 2, E.

Instar 2: Head dark fuscous to black, mouth parts a little paler. Cervical plate dark fuscous, transverse, about twice as long as wide, rounded laterad and with a round dark spot in the center of each [illegible]. Body color pale yellow

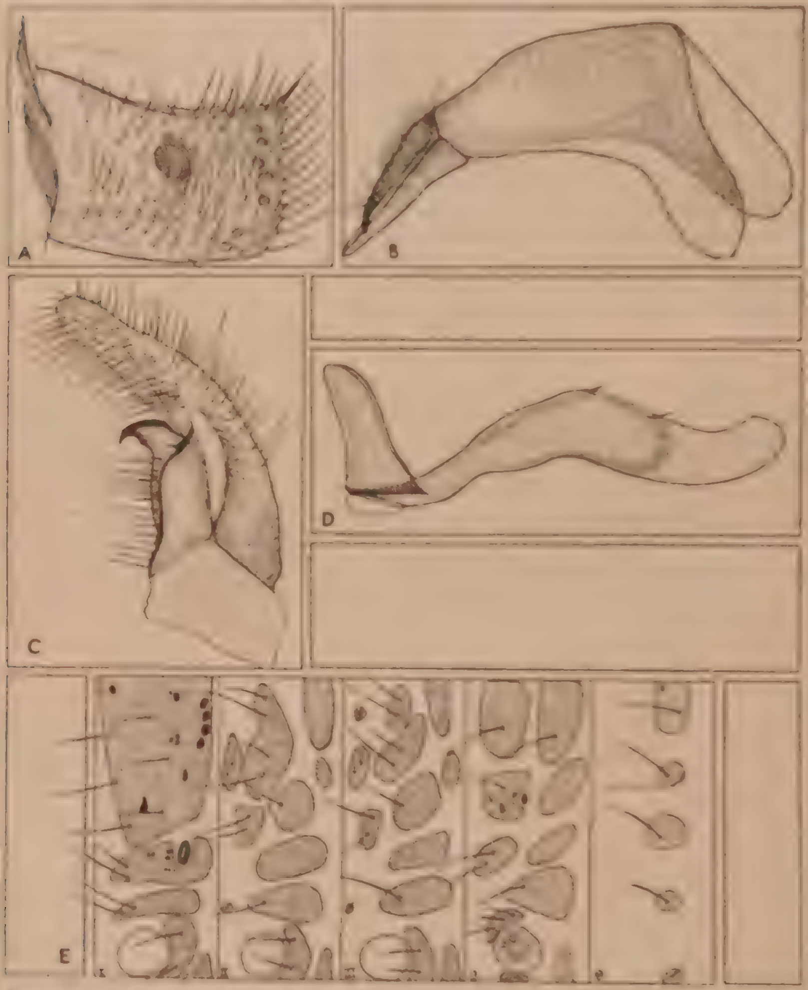


FIGURE 2.—The blueberry webworm ([illegible]): A, [illegible] segment of male moth; B, [illegible]

overlaid with rufous, giving the whole larva a brownish-red appearance, the overcolor more or less broken and mottled at sutures and along the sides of the body. The ingested food adds a greenish tinge and the dorsal vessel shows a narrow dark line. Segments of thorax and abdomen well marked, those of the former each bearing a transverse row of six small pinacula and those of the latter with six pinacula on the anterior lobe and a single more widely spaced pair on the posterior lobe. The caudal segment bears a dorsal subquadrate setigerous plate. Skin of thorax and abdomen finely granular or punctate.

Instar 3. Head [illegible] darker than body.

Instar 4. Head dusky yellow, [illegible]

Instar 5. Head dusky yellow with an indefinite pattern of darker [illegible] brown markings, [illegible] mouth parts dark. Cervical plate [illegible] yellow, mottled with darker spots, slightly darker than head. Body purplish, with spiracles, and cicatrices on pedal segments, black. Pinacula concolorous with skin and not conspicuous except the small dark spots surrounding each seta. Caudal plate pale with blackish spots.

Instar 6. Head dusky yellow with an indefinite pattern of darker areas. Cervical plate dusky yellow, slightly darker than body color. Body color dusky yellow tinged with green by the body contents, skin dull, finely granular. The purplish overcolor has largely been lost, and the larva at this stage begins to develop the body color and arrangement of pinacula which characterize it. [illegible]

Instar 7. The description of this instar [illegible] others studied.

[illegible]

## THE PUPA

There is nothing especially distinctive about the pupal stage of this species. (Fig. 3.) When the larva has completed its growth it

abandons its feeding burrow and constructs a cell in the earth near by, usually within an inch or two of the plant upon which it has been feeding. This cell is lined loosely with gray silk and forms the cocoon. It is oval, with the larger end down, stands vertically in the earth, or nearly so, and, with the adhering earth, is about 14 mm. long and 6 mm. wide. It is not substantially made and rarely retains its shape when dug up. It is built so near the surface that no neck or extension is needed to allow the moth to escape. In this cocoon the pupa is formed with the head uppermost.

The length of the pupal stage ranges from 5 to 16 days, the usual period in midsummer being 7 or 8 days. Although somewhat longer in the cool weather of spring and fall, the extent to which this prolongation is possible seems quite limited, and pupae held at low temperatures for any period in excess of the maximum given in Table 3 invariably died. A detailed description of the pupa is nearly a repetition of those given for other species, except that the caudal process of cremaster is straighter and somewhat more distinct than with the others. It is narrow, sharply constricted beneath, and straight above.

FIGURE 4.—Moth of the bluegrass webworm. × 3

When the moth (fig. 4) emerges the empty pupal skin remains wholly within the cocoon.

DESCRIPTION

Length 8 to 10 mm.; width 2.5 mm. General color amber yellow, each suture marked with a fine narrow line, thus making the exact shape of the various organs easily distinguishable. Entirely glabrous except for the very minute setae on cremaster.

Vertex slightly bilobed, eyes slightly produced, labrum at base three times width at tip, femur of the prothoracic legs apparent for a short distance between the maxillae, and the tarsi of the prothoracic legs visible for a short distance beyond the maxillae and between the tarsi of the mesothoracic legs. On the venter only abdominal segments 4 to 9 visible, no suture between the eighth and ninth. On the dorsum spiracles are visible on the second to seventh segments, those on 2 and 3 lying close to the margin of the hind wings, which are narrowly exposed beyond the posterior margins of the anterior pair. Cremaster a rounded process, flattened slightly dorsoventrally, bearing at its tip two widely separated diverging minute setae and dorsocephalad of these two more still smaller. At the base of the cremaster, dorsad on each side is a short, deep, slightly curved groove.

## THE MOTH

### HABITS

During the season of their abundance the moths are found in almost every possible location, but they are most numerous in meadows, in pastures, and on waste land. They are free fliers and evidently travel considerable distances, judging from the numbers that often gather at lights. During the day they are not often seen unless disturbed, but on cloudy days and late in the afternoon, toward dusk, they are easily flushed and fly freely. As a resting place they prefer broad-leafed plants to grass, and almost invariably alight on ironweed, goldenrod, ragweed, etc., when such plants are available. They often alight on the upper surface of the leaves, but immediately scuttle beneath and come to rest with the head pressed closely to the surface

and the abdomen and wings elevated at an angle of 25°. This characteristic posture, and the white scales on the top of the head, visible at a considerable distance, easily distinguish this species from any others with which it may be associated in the field. The moths vary widely in size, the females invariably averaging larger than the males. Some of the males, especially those maturing during dry periods in midsummer, are very small, scarcely half the size of the largest males produced at more favorable seasons. Aside from their smaller size, the males are easily distinguished from the females by the shorter and broader antennae, those of the females being setaceous.

### REACTION TO LIGHT

Throughout the region of its occurrence this species is more strongly attracted to light than any of its congeners, with the possible exception of *Crambus trisectus* Walk. When weather conditions are favorable the moths come to lighted house windows and porch lights by hundreds and sometimes literally by thousands, at times interfering seriously with the comfort of those who wish to use their porches. In 1915, at Nashville, Tenn., over 7,000 moths were collected at the windows of one small building during one night.

Because of its abundance and strong positively phototropic tendencies, the species provided a good subject for the study of this characteristic, and also of the possibilities of using trap lights as a means of control of this and related species. During the summer of 1916, at Nashville, Tenn., Mr. Cartwright and the writer made a series of all-night collections of these moths at light. The collections of each 15-minute period were kept separate, and the sex of each moth was determined. The detailed results have been given in a previous paper (2). The conclusion arrived at was that the great majority of the female moths came to light early in the evening, coming in greatest numbers about 30 minutes after it became dark enough for the light to attract. The males, on the other hand, came in very small numbers early in the night but reached their maximum flight between 11.15 p. m. and 1 a. m. At 10 p. m. only 15 per cent of the total number of males taken had appeared, whereas 60 per cent of the total number of females taken had come.

Although it seems certain that meteorological conditions, or certain combinations of them, have great influence on the number of moths coming to light at any given time, the writer was unsuccessful in determining the deciding factor. It was repeatedly noted that of two nights under very similar weather conditions there might be on one a profuse flight of moths whereas on the other they would be very scarce. Much work remains to be done along this line, as well as on the relative attractiveness of different colors and kinds of light.

### FEEDING

Observations in the field and experimental evidence unite to show that in nature the moths do not feed except possibly on water in the form of dew or raindrops. In numerous experiments, moths, both males and females, were kept in cages, dry, with water alone, and with diluted honey available as food. In every case those kept in dry vials or boxes died first and, if females, laid the fewest eggs. Those offered dilute honey came next, and those with water available lived

longest and laid the greatest number of eggs. Aside from an occasional individual accidentally present, the writer has never taken these moths at sugar or other bait put out as an insect attractant, and they are not attracted to flowers. Those kept in boxes with dilute honey available did feed, but apparently as much for the sake of moisture as for the honey, and the addition of the latter resulted in no increase either of longevity or of fecundity.

## FECUNDITY

The ovary consists of 8 ovarioles arranged in 2 groups of 4 each, opening finally into the common oviduct. The tubes or ovarioles are so arranged in the abdomen that each is divided into 4 sections by 3 bends. In a freshly emerged moth the first 2 sections contain large, white eggs, fully matured and ready for oviposition, these being about 5 to a section. The third contains about 10 partly developed ova of approximately half the size of those in the first 2 sections. They contain some opaque white matter, but are partly transparent. The last section is the narrow extremity of the tube and contains about 15 or more very small, transparent egg cells, gradually decreasing in size until they merge into the transparent fiber of protoplasm which terminates the tube. There are thus about 35 discernible eggs in various stages of development in each ovariole, or about 280 in the entire ovary. The ovary and surrounding space in the abdomen are packed with small, white fat masses. The quantity of this fat varies greatly in different moths and is apparently dependent on the abundance and quality of the food supply during the larval life. A study of many dissections of fresh and spent moths shows that the fat, the more immature ova, and even the ovarioles themselves, and other organs, are gradually absorbed as oviposition progresses until finally the eggs are all matured or absorbed, and the abdomen is practically empty. When this point is reached oviposition necessarily ceases, and the vitality of the moth is so completely exhausted that death soon ensues.

The eggs of all the species of Crambus vary little in size, and the number which one female can produce seems to be proportional to her own size. As *C. teterrellus* is one of the smaller species, and the eggs are probably larger than the average for the group, this species lays proportionately fewer eggs than do the larger species. The egg-laying records of several hundred moths captured in the field and at light are available, as are also those of many reared individuals. The largest number of eggs recorded from a single moth of this species is 564. This moth reached probably about the extreme limit for the species, it being the only one that produced more than 500. Three others produced over 400 each and 10 others over 300. These records were all made by moths collected in the field or at light and kept confined individually in tin boxes with a wad of wet cotton. A few of those given dilute honey laid more than 300 eggs each. Of 350 moths taken in the field and kept in dry boxes or vials, none laid as many as 300 eggs, and only 23 laid more than 200. Only 18 of this lot laid no eggs at all.

The average number of eggs obtained from the 350 moths mentioned above, collected in the field and kept in dry containers, was 79. The average obtained from 104 moths collected in the field and kept

in boxes with wet cotton was 156, which is still below the number actually produced, because many of the moths doubtless had disposed of a considerable number before capture. Judging from all the data at hand, the number of eggs produced by the average moth of this species under normal conditions is probably between 200 and 250.

The eggs are laid during a period beginning at about 4 p. m. and reaching the maximum rate of production shortly after dark. After midnight only a few eggs are laid, and with the coming of dawn oviposition ceases altogether, not to begin again until afternoon. The writer has noted many times that even though moths were confined in light-tight tin boxes and kept in a dark place, they could not be induced to oviposit until the proper time of day arrived, when their behavior in this regard would correspond exactly with that of moths in the open. The egg-laying mechanism is apparently quite independent of the will of the moth, and is set in operation by some factor connected with the approach of evening and independent of the waning light and declining temperature. Further evidence of this is afforded by the observation that if female moths about the light are disabled by a tap of the finger on the thorax sufficient eventually to kill them, oviposition continues without cessation often for a half hour or more. Some moths treated in this manner laid nearly 100 eggs each before all motion ceased.

The number of eggs laid in any one day varies greatly. In several instances over 200 have been laid by one moth within 24 hours, and 100 or more is a common record. The records of two reared moths given below indicate what occurs when moths are kept under conditions as nearly natural as possible. One moth, which emerged August 3 laid her first eggs on August 7 and daily thereafter, with one exception, the entire count being as follows: 5, 4, 3, 5, 8, 14, 10, 9, 11, 60, 0, 5, 13, 9, and died on August 21, with a life period of 18 days, having laid a total of 156 eggs. Dissection after death showed 5 mature eggs still in the oviduct. Another, emerging August 7, lived 29 days, laying during that time 269 eggs, beginning August 10 as follows: 5, 5, 8, 9, 12, 11, 21, 3, 21, 31, 56, 21, 11, 17, 10, 11, 7, 4. She lived until September 5, but produced no eggs after August 27, and when dissected her abdomen was practically empty.

## MATING

The mating habits of these moths have been observed on several different occasions, but always under similar conditions. Quotations from notes made on September 12, 1914, will best describe the action.

> On the screen and windows of the laboratory these moths were observed mating this evening. The screens were swarming with the moths attracted by the light. The insects make flutter up the screen half walking and half flying. When they approach another moth the genitalia are suddenly extruded, and the mass of long slender scales inside the outer sheath open out, causing the end of the abdomen to appear as bushy as a small chrysanthemum. The abdomen is extended and turned outward and forward so the genital organs face forward. Sometimes the abdomen is bent so far around that the movements of the legs on that side are interfered with, and the moth is walking sideways over its own body. The moth approached, either male or female, is disturbed and moves forward a few steps. The male flutters after it and, while headed in the same direction as its prospective mate, reaches under the wings and searches for the tip of the other's abdomen. If this one happens to be a female and it is receptive, union is soon made, and the male at once drops his wings over those of the

female and swings around until he is headed in the opposite direction from his mate. The female, being the larger, is able to drag the male about at will. The males in search of mates frequently follow and seem to unite with other males. There seemed to be no selection practiced. As soon as the union is made and the moths have assumed their normal positions, they become motionless and remain so until the act is complete, or nearly so. The female gives the first indication of uneasiness, vibrating the wings and twisting the abdomen. Usually this occurs two or three times, for a moment each, until finally the moths separate. After the pair separates each remains more or less quiet for some time, the male appearing weakened.

Many of the males die within from 12 to 24 hours after mating. The mating seems to take place rather spasmodically and only when the moths are fairly abundant on the window. For some time none will mate, and then in a minute or two several couples will form. Mating does not begin until the evening is well advanced. One night when especially careful watch was made the first pair was noted at 9 o'clock. This is perhaps explained by the fact that the males do not make their appearance in any numbers until about that time. If no moths are removed, but all are allowed to accumulate on the window, by midnight or later the numbers of the two sexes are approximately equal. In the case of 25 couples under observation the duration of the union ranged from 12 minutes to 2 hours and 20 minutes, with an average of 66 minutes.

It seems probable that each female mates but once, and this may also apply to the males. Females confined in a cage with males for only a short time after emergence and then isolated lay fertile eggs for several days, apparently until their supply is exhausted. Also, it is evident that in nature mating takes place very shortly after the emergence of the moth, for among the hundreds of females collected at light and in the field, very seldom was one found whose eggs were not fertile.

## LONGEVITY

It is impossible to determine exactly how long the moths live in their natural surroundings. Several hundred moths, some reared, but most of them collected in the field and at light, were kept under various conditions to determine as closely as possible their natural span of life. This undoubtedly varies greatly. Individuals passing their larval life in situations where food was suitable and abundant emerge as larger moths and with much greater reserve stores of fat than those partially starved during their larval lives. Most of the moths studied were kept in one of the following ways: In dry vials or tin boxes; in tin boxes or open cages with a pellet of cotton saturated with clear water; or in similar boxes or cages with the cotton saturated with diluted honey. In all three situations the females lived appreciably longer than the males, the average difference being a little more than one day. Those kept within reach of water lived longest, and the difference between the dry and the honey-fed moths was so slight as to prove conclusively that the nutritive value of the honey was of no benefit. The longest life of any individual moth was 29 days. This individual was a female which emerged in a breeding box August 7, and was fed with dilute honey. In an open cage provided with clear water one female lived 28 days, another 23, and a male lived 25 days. The longest life recorded for a moth without moisture was 19 days—in this case a female that was fed abundantly as a larva and emerged in one of the tin-box

breeding cages. No moth taken in the field and given [illegible] lived more than 12 days after capture.

Table 2 condenses all the writer's records on this point in a form suitable for comparison. From observations in the field it is surmised that under conditions entirely normal the life of a moth is from 7 to 10 days.

TABLE 2.—Number of moths of *Crambus teterrellus* (of a total of [illegible] observed) [illegible] living in cages the number of days specified, under three conditions of nourishment: dry, [illegible]

| Length of life in cage (days) | Number of moths of each sex living the days specified under given conditions of nourishment: In dry enclosure, Male | In dry enclosure, Female | With water, Male | With water, Female | With honey, Male | With honey, Female |
|---|---|---|---|---|---|---|
| 1 | 4 | 6 | 2 | 2 | ..... | 3 |
| 2 | [illegible] | 94 | 23 | 39 | 39 | 60 |
| 3 | [illegible] | 60 | 20 | 26 | 19 | 31 |
| 4 | [illegible] | 110 | 9 | 60 | 10 | 70 |
| 5 | [illegible] | 34 | 12 | 22 | 6 | 20 |
| 6 | [illegible] | 63 | 12 | 21 | 7 | [illegible] |
| 7 | [illegible] | 23 | 7 | 16 | 2 | 10 |
| 8 | 4 | 21 | 7 | 19 | 1 | 11 |
| 9 | [illegible] | 11 | 6 | 9 | | 3 |
| 10 | [illegible] | 17 | 4 | 13 | 2 | 3 |
| 11 | | 3 | 4 | 5 | | 1 |
| 12 | | 5 | 4 | 2 | 1 | 1 |
| 13 | | 2 | | 6 | | |
| 14 | | | 2 | 4 | | |
| 15 | | | 2 | 1 | | |
| 16 | | [illegible] | 1 | 2 | | |
| 19 | | 1 | | | | |
| 20 | | | | [illegible] | | |
| [illegible] | | ..... | 1 | | ..... | |
| [illegible] | | | | 1 | | |
| Total | 377 | 485 | 125 | 244 | 74 | 160 |
| Total days lived in cage | 1,[illegible] | 2,245 | 694 | 1,300 | 261 | 738 |
| Average life in cage, days | [illegible] | 4.63 | 2.47 | 5.73 | 3.53 | 4.57 |

DESCRIPTION

Wing expanse 15 to 21 mm. Palpi and head above white, paler beneath, thorax, and abdomen pale cinereous. (Fig. 1.) Fore wing cinereous with a tinge of [illegible] more pronounced in some specimens than in others, [illegible] darker and with numerous [illegible] of blackish scales especially in the [illegible] and just below. Median line orange, running from just beyond the middle of the anterior margin to the tip of the cell, thence to the middle of the inner margin, with an outward angle at the fold. Subterminal line orange, edged [illegible] with white, running from a point midway between the median line and the tip of the wing to near the basal angle, with an obtuse angle a little above the middle. Between the median and subterminal lines the intervenular spaces are more or less prominently marked with orange scales and edged with black, veins lined with white. Terminal line of seven black intervenular dots, the spaces between it and the subterminal line covered with white scales tipped with black, giving this area a salt-and-pepper appearance very characteristic of this species. Fringe cinereous with a golden tinge. Hind wings uniformly pale cinereous with white fringes. Fore wings beneath uniformly dark cinereous, with small darker terminal intervenular dots. Hind wings beneath paler than the fore wings, with a narrow brown marginal line. Antennae of female [illegible], of the male [illegible] and broadened, each segment extended laterally so as to give it the general shape of an ax head. Near the center on both the upper and lower faces of the segments (fig. 2, A) is a compound sensorium consisting of one large sensorium closely surrounded by a varying number of others similar in size and structure to those found on other species and elsewhere on the same segment in *Crambus teterrellus*.

On the more highly developed segments near the middle of the antennae the group may be composed of as many as 10, or even more, of the smaller sensoria. Toward either extremity the number decreases until only two or three occur in each group. Under low magnification this compound sensorium shows merely as a distinct dark spot, and Fell ([illegible], pl. [illegible], fig. [illegible]) has so represented it. No compound sensorium has been met with in any other species examined.

Genitalia, male: Tegumen (fig. 2, B) with [illegible] broad and short, rounded distal; body long and broad; uncus rather slender, setigerous above and at base and along margins, terminating in a long, strong, gently curved hook, which [illegible] only a little of reaching the tip of the gnathos; gnathos also rather slender, naked, tapering evenly from the base to a narrow truncate apex. Harpes (fig. 2, C) somewhat convolute at base, the free arms much shortened and truncate at tip, with the angles produced into short incurved hooks, costa rather narrow, fingerlike and densely hairy above. Sacculus not sharply differentiated, but reaching the base of the costa with a rounded, more heavily chitinized lobe bearing a group of short, stout spines. Vinculum weakly chitinized and rather large but not sharply differentiated. Aedeagus (fig. 2, D) not heavily chitinized, slender and tapering toward each end. Cephalic end evenly rounded, and produced cephalad of the dorsal opening for the penis; caudal end obliquely truncate with the opening for the egress of the penis ventrad. From the caudal extremity arise two large flat chitinous processes curving outward and upward to much the shape of a horseshoe and, so far as is known, entirely unique with this species. There are no cornuti. The anellus (fig. 2, E) is a definite [illegible] chitinous plate, accurately filling the opening between the bases of the harpes and the tegumen, and with an elliptic hole through which the aedeagus passes.

Female: Anal plate much narrower than long, narrowly rectangular, with the apex only slightly produced.

Although none of the moths are conspicuously marked, the wing pattern in some is much more distinct than in others. The general color varies from a light fawn to a dark earthy brown. The marking of the subterminal area is characteristic of this species, and is sufficient to make certain determination of specimens possible, even if no other portion is available. As they become worn, the moths of both sexes appear lighter in color, but, either because they live longer or are more active, the females become badly rubbed much more commonly than the males. The points which conspicuously differentiate this species from its congeners are the characteristic marking of the subterminal area on the wing, the white scales on the top of the head, and the resting position with the body held at an angle of 25° with the surface. Furthermore, the compound sensoria on the antennae and the peculiar processes on the extremity of the aedeagus seem to be wholly unique with this species.

## PARASITES AND PREDACIOUS ENEMIES

Because of the failure, so far, to devise any satisfactory method of collecting the larvae of these moths in quantity from their burrows, very few have been reared except those hatched from eggs in the laboratory. It is due to this fact, rather than to their scarcity, that very few parasites have been reared from *Crambus teterrellus*. There are without doubt many more species than have been recorded that attack the host, not only of internal parasites but also of predacious enemies and fungous and bacterial diseases.

### PARASITES

In a breeding jar containing larvae of various stages collected from the lawn, Murtfeldt (*14*, *p. 54*) found "the remains of two or three hymenopterous parasites and four cocoons of the characteristic form, color, and structure of Meteorus, closely resembling those of *M.*

*hyphantriae*." These parasites seem never to have been definitely determined, and no others of the kind have been recorded. A larva of *Crambus teterrellus* found feeding on a plant of orchard grass (*Dactylis glomeratus*) at Nashville, Tenn., May 11, 1914, had on May 28 constructed a pupal case in the earth. In this pupal case was found the empty skin of the host and a brown cocoon of a parasite. The cocoon was 12 mm. long and 4 mm. in diameter, cylindrical with rounded ends, and lined inside with white silk. The cocoon was loosely spun, so that the body of its maker could be seen within, but not with sufficient distinctness to tell whether it was a larva or a pupa. The adult parasite emerged June 8, and was determined by A. B. Gahan as *Cymodusa mississippiensis* Ashm.

#### PREDACIOUS ENEMIES

Attempts were repeatedly made to interest ants in the eggs of this species, it being supposed that as the eggs are dropped promiscuously in the grass ants must often run across them. Only one such attempt was successful, and in this instance eggs dropped near the entrance to their burrow were eagerly seized and carried inside by small brown ants, a species of Pheidole. An unsuccessful endeavor was made to find what became of the eggs. Other ants paid no attention whatever to them.

Robber flies, determined by Aldrich as *Erax aestuans* L., have many times been seen capturing moths of this and other species of Crambus. The flies wait at some exposed point and, when a moth flies near enough, dart out and seize it, returning to their perch to consume it at their leisure.

In one instance a larva of *Chauliognathus pennsylvanicus* DeG. was captured, partly within a pupal case, also within which was found the partially consumed body of a larva of *Crambus teterrellus*.

### SUGGESTED CONTROL MEASURES

No practical methods of control have been devised for this or other species of Crambus larvae working in sod lands. Attempts to kill them with poisoned-bran bait in various combinations seemed fruitless. It is possible that if the bran bait can be mixed with some substance which is a strong attractant for the larvae they can be reached. Such a substance has been suggested in nitrobenzene, first used for this purpose by A. C. Morgan at Clarksville, Tenn., for the control of the larvae of *Crambus caliginosellus* Clem. attacking young tobacco plants. Since this information has been available no opportunity has presented itself to test the method with other species, but it is well worth the attempt.

Although it would probably not be feasible to operate light traps solely for the control of this insect, studies of its night habits indicate that such lights operated from dusk until midnight would capture large numbers of gravid female moths and prevent the deposition of vast numbers of eggs.

### SUMMARY

The bluegrass webworm is so called because it is most abundant in the sections of the country where bluegrass is a dominant plant species and because it is found feeding principally upon it. The adult is a small grayish moth.

It was described in 1821, but has attracted very slight attention from entomologists, and its complete bibliography is very short.

It is widely distributed in the eastern and the southeastern parts of the United States, and in several States is probably the most abundant species of moth.

Its economic importance is undoubted. In ordinary seasons it is a cause of serious depletion of pastures, and in dry years may be the real cause for the complete killing out of sod in pastures and lawns.

Under ordinary conditions there are three broods each year, but individuals vary so greatly in their rate of growth that progeny of a single moth may cover one, two, or three generations in the same season. The principal flights of the moths occur in May, July, and September.

The egg is similar to the eggs of other species of the genus, but averages slightly larger. The larvae construct flimsy tubes of silk and earth particles, in which they remain during the day, emerging at night to feed. The normal number of instars for this species seems to be eight, although there is great variation. As many as 20 instars have been observed in the case of some specimens, but in such instances there was no increase in size after the eighth instar.

Kentucky bluegrass is by far the most commonly infested food plant although other grasses are eaten readily. No food plants other than grasses are known to be eaten.

The pupae are formed in loosely made pupal cases constructed separately from, but near, the feeding burrow. The moths become active about dusk, and are attracted to lights in large numbers. They do not feed, except possibly on water.

Eggs are dropped promiscuously. The average number produced by one moth is probably about 200 or 250, although one moth laid 564. The moths mate at night; mating was observed only when they were abundant around lights. The normal life of a moth is from 7 to 10 days.

In the investigation here reported only a single parasite was reared, *Cymodusa mississippiensis* Ashm. Several predacious enemies were observed feeding on both larvae and adults.

The use of ordinary poisoned-bran bait gave no apparent results in the control of the larvae, but by combining it with some attractive substance it is possible that an effective bait may yet be devised.

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